"The Chemical Society of Philadelphia, instituted in 1792, was undoubtedly the earliest organized body of chemists in either hemisphere."

H. C. Bolton.

On October 24, 1801, a committee of this society was appointed "for the discovery of means by which a greater supply of heat might be obtained for chemical purposes." On this committee was placed Robert Hare then only 20 years of age. On December 10 he reported to the society on behalf of the committee his invention of the oxy-hydrogen blow-pipe, a service to chemistry that of itself alone justified the existence of the Society.

MEMOIR

ON THE

SUPPLY AND APPLICATION

OF THE

BLOW-PIPE.

CONTAINING

AN ACCOUNT OF A NEW METHOD OF SUPPLYING THE BLOW-PIPE EITHER WITH COMMON AIR, OR OXYGEN GAS: AND ALSO OF THE EFFECTS OF THE INTENSE HEAT PRODUCED BY THE COMBUSTION OF THE HYDROGEN AND OXYGEN GASES.

ILLUSTRATED BY ENGRAVINGS.

PUBLISHED BY ORDER

OF THE

CHEMICAL SOCIETY OF PHILADELPHIA;

TO WHOM

IT WAS PRESENTED,

BY ROBERT HARE, JUN.

CORRESPONDING MEMBER OF THE SOCIETY.

PHILADELPHIA,

PRINTED FOR THE CHEMICAL SOCIETY,

BY H. MAXWELL, COLUMBIA-HOUSE.

1802.

INTRODUCTION.

ON the 24th of October, 1801, a committee, of which I was a member, was appointed by the Chemical Society, for the discovery of means, by which a greater concentration of heat might be obtained for chemical purposes.

The committee thus appointed, soon after informed the Society, that as they had conceived, that the only way of attaining the object of their appointment, would be to precipitate more copious supplies of oxygen gas, into any focus of combustion; they had therefore confined their attention to the exhibition of a machine, by which this would be much facilitated.

This machine had been previously invented by me; and I was induced, by the recommendation of my colleagues, to subject it to the attention of the Society.

The Society, honoured the report of the committee with a favourable reception; ordered them to procure an engraving of the machine; and that this, together with an explanation of it, should be laid before the public.

These commands of the Society, would have been long since complied with, but that experiments suggested themselves, the execution of which has demanded time. Some of these experiments appear to invalidate the opinion, that the precipitating of larger supplies of oxygen gas, into any focus of combustion, would be the only way, by which the intenseness of caloric could be increased to a degree not before attained.

On the tenth of last December, I informed the Society of my having conceived, that a more intense heat might be obtained, by the united combustion of hydrogen, oxygen, and carbon, than had been before produced: and I, at the same time, laid before them an improvement of my machine, which tended much to facilitate the application of the hydrogen, and oxygen gases to this joint combustion.*

Still continuing my experiments on that subject, I was afterwards enabled to produce to the Society, fused specimens of native lime, and pure magnesia; and to inform them, that barytes, alumine, and platina, were susceptible of rapid fusion.

An account of the result of these, and other experiments, on the supply and application of the Blow-Pipe; together with an engraving, and an explanation of the apparatus, by which they were effected; are the subjects of the following paper.

* Extract from the minutes of the Chemical Society, of the tenth of December, 1801.

" Mr. Hare then called the attention of the Society, to some improvements in his newly invented Hydrostatic Blow-Pipe; by which he was enabled to exhibit, the combustion of the hydrogen, and oxygen gases; the heat thereby produced, being very intense."

J. H.

Rec. Sec.

MEMOIR

ON THE

SUPPLY AND APPLICATION

OF THE

BLOW-PIPE.

CHAPTER I.

IMPORTANT USES OF THE BLOW-PIPE—IMPERFECTIONS OF THE MEANS HITHERTO EMPLOYED, FOR SUPPLYING IT WITH AIR—INVENTION OF A MACHINE, FREE FROM THOSE IMPERFECTIONS.

THE Blow-Pipe is, on many occasions, an useful instrument, to the artist and philosopher. By the former it is used, for the purpose of enamelling, to soften or solder small pieces of metal, and for the fabrication of glass instruments: while the latter can, by means of it, in a few minutes subject small portions of any substance to intense heat; and is thereby enabled to judge, of the advantage to be gained, and the method to be pursued, in operations on a larger scale. The celebrated Bergman has amply displayed the utility of this instrument, in docimastic operations; and with the perfection of the docimastic art, the improvement of metallurgy is intimately connected. It is by means of the Blow-Pipe, that glass tubes are most conveniently exposed to the heat necessary to mould them into the many forms occasionally required for philosophical purposes; and by the various application of tubes thus moulded, ingenuity is often enabled to surmount the want of apparatus, which is the greatest obstacle to the attainment of skill in experimental philosophy.

To all the purposes which I have mentioned, the Blow-Pipe is fully adequate, when properly supplied with air, and applied to a proper flame: but it appears that the means which have hitherto been employed to accomplish those ends, are all faulty.

The most general method, is that of supplying this instrument with the breath. In addition to the well known difficulty of keeping up a constant emission of air during respiration, and its injurious effect on the lungs;* it may be remarked, that as the breath is deprived of part of its pure air, is mixed with carbonic acid gas, and loaded with moisture, it is not the most fit for combustion; and the obvious impossibility of supporting a flame with oxygen gas, by this method, is also worthy of consideration.

* In consequence of this, some artists have abandoned the use of the instrument.

Another way of supplying the Blow-Pipe with air, is that of affixing to it a small pair of double bellows. A contrivance of this kind possesses obvious advantages over the mouth Blow-Pipe; but, owing to the pervious nature of the materials of which bellows are constructed, and the difficulty of making their valves air tight, upwards of nine tenths of the air drawn into them, escapes at other places than the proper aperture. A pair of bellows of this kind, belonging to an artist of this city, which were considered as unusually air tight, were found to discharge the complement of their upper compartment, in six-fourths of a minute, when the orifice of the pipe was open; and in seven-fourths of a minute, when it was closed. Hence it appears, that six-sevenths of the air injected into the upper compartment, escaped at other places than the proper aperture; and if to this loss, were added that sustained by the lower compartment, the waste would be found much greater. As in operating with these machines, it is necessary constantly to move the foot, the operator cannot leave his seat; and in nice operations, the motion of his body is an inconvenience, if not a source of failure. Bellows of this kind cannot be used for supplying combustion with oxygen gas; because, as this air is only to be obtained by a chemical process, the smallest waste of it is of serious consequence; and as there is always a portion of air remaining in them, even when the boards are pressed as near to each other as the folding of the leather will permit, any small quantity of oxygen gas which might be drawn into them, would be thereby contaminated.

It seems, that the only instrument hitherto used, for the supply of combustion with oxygen gas, is the gazometer of the celebrated Lavoisier: but this machine, although admirably calculated for the purposes of that great philosopher, is too unwieldy and expensive, for ordinary uses.

Being sensible of the advantage which would result, from the invention of a more perfect method of supplying the Blow-Pipe, with pure, or atmospheric air, I was induced to search for means of accomplishing this object. Having observed the cheapness, strength, and tightness, of coopers' vessels, I became desirous of forming an apparatus for my purpose, by means of hydrostatic pressure, exerted within them. I soon found, that this could not be effected conveniently, without the use of leather. Obliged to resort for assistance to this material, I endeavoured to apply it in such manner, as to remedy the evils resulting from the use of it, in the common kinds of bellows. The causes of these evils appeared to be, the opening of the pores and joints of these instruments, by dryness, and the tension to which they are so frequently subjected. I therefore determined to subject the leather, which I should use, to moisture and compression. In this I succeeded, and derived the expected advantage from success. The result of my attention to this subject, is the production of a machine, of which there follows an engraving and description.

HYDROSTATIC BLOW-PIPE.

Engraved for the

CHEMICAL SOCIETY of PHILADELPHIA;

by James Akin, after Drawings made by himself from the Originals in y.e Inventor's possession.

When it was first shewn to the gentlemen of the Chemical Society, some of them bestowed on it the appellation of Gazometer; but, as etymology does not authorize this name, it has been changed for that of Hydrostatic Blow-Pipe.

CHAPTER II.

EXPLANATION OF AN ENGRAVING, OF THE HYDROSTATIC BLOW-PIPE.—ACCOUNT OF THE MANNER, AND PRINCIPLE OF ITS ACTION.

FIG. 1, (see plate) is a perspective engraving of the Hydrostatic Blow-pipe.—Part of this figure is made transparent, that the internal construction of the machine, may be understood with the greater facility.

It consists of a cask A, whose length is thirty-two, and whose least diameter is eighteen inches. It is divided, by the partition B, into two apartments. The upper, and external apartment B A, is in depth fourteen inches. The lower, and internal apartment, B C, is in depth sixteen inches; and contains a sheet and pipe of copper E E, D, which descend into it nine inches, forming two equal compartments of that depth. The sheet and pipe of copper are soldered together, and inserted into the partition B, as may be observed at Fig. 2; where B represents the partition; E E the sheet of copper; and D the pipe. The edges, E E, of the sheet, were slid down into corresponding joints in the staves of the cask, until the partition attained its proper situation. Coopers' flags were then passed into the joints; and the hoops were driven on the cask.

C F, Fig. 1, is a pair of circular bellows. The bottom of the cask, serves as a bottom for these bellows.

In the center of this bottom, there is a hole; round which, at the distance of one inch from its center, is a circular rim of wood. On this is nailed a valve opening upwards, which may be observed at B, Fig. 3, where there is a transparent engraving of the bellows. Under the valve B, may be observed the hole, and circular rim of wood, over which it is nailed.—C the top of the bellows, is a circular piece of wood, seven inches in diameter, and two in thickness. In its center there is a hole, one and a half inches in diameter. Around this hole there is a circular rabbet, in which is nailed a valve, opening upwards. This valve, and the rabbet in which it is fastened, may be seen under the letter D, at the end of the rod. There is also in this top, at the distance of one inch from its perimeter, a circular dovetailed furrow filled with lead E.—The body of the bellows F F, is composed of strong hose leather, sewed so as to be water-tight. Before it was fixed to the other parts of the bellows, its form was that of a hollow frustum of a cone; of which the perpendicular, and greatest diameter, were each eight inches; and whose least diameter, was six and a half inches. It was more easily fastened to its appendages, when of this conical form, than if it had been cylindrical. At the protuberances F F, it is distended by two iron rings, to which it is sewed fast.

F G, Fig. 1, is an iron rod, by means of which, the top of the bellows may be raised or depressed. It passes up through the pipe D, to the handle G, which is worked by the hand, or with the foot, by means of the pendent stirrup. An enlarged view of this rod, and of the contrivance by which it is annexed to the top, may be seen at fig. 3; where G D represents the rod, and H, H, H, H, flat pieces of iron branching from it. These are fixed to the circular rim K K, in such manner as to include the rim I I, of the same metal, which is screwed fast to the top of the bellows. Sufficient room is left, to allow the pieces H, H, H, H, and the rim K K, to move round without rubbing against the included rim I I, or the top of the bellows.

A copper hood, with an opening in one side, may be observed at L, Fig. 3. The rod G D is passed through the center of this hood, until the flat pieces of iron H, H, H, H, come in contact with the flat part of it. The hole in the center is then luted. The hood may be seen in its proper situation, at F, Fig. 1.

H I, Fig. 1, is a suction pipe half an inch in diameter. It passes under the cask, in the direction of the dotted lines at C, and turns up into the hole in the bottom of the bellows. This hole, which is of such a size as to fit the tapering end of the pipe, is seen at Fig. 3, and has already been mentioned, together with a circular rim of wood, which being nailed round it, prevents the end of the pipe from touching the valve. The suction pipe has a conical mouth at I; into which is inserted occasionally, the pipe J, fastened to the hose and syphon K, L. The hose is made of leather, distended by hollow cylinders of tin, half an inch in diameter, and one inch in length. These were coated with tar, after which the leather was sewed over them*.

Fig. 1. M N O, m n o, are pipes of delivery, furnished with cocks at N, n, and conical mouths at O, o. Each of these pipes, communicates with one of the compartments on each side of the sheet and pipe E E, D.

In the partition B, may be observed the pipe Y furnished with a cock. Each end of this pipe, communicates with one of the compartments abovementioned.

P is a table affixed to the cask by means of irons, which are at pleasure slid into, or out of staples. One of these irons, and its staples, may be seen near the letter Q. They are fastened to pieces of wood, which run lengthwise under the table, and which are so grooved, as to support a block of wood, which slides between them. Through this block passes the screw S; which slides backward and forward in the opening T R V.—The stand T V, which may be observed under the lamp, is loosely put on this screw, as a wheel is placed on its axletree. It rises and falls with the screw; but is prevented from turning round with it, by the upright strip of wood T.

Having described the construction of the Hydrostatic Blow-Pipe, I proceed to an explanation of the principle, and manner of its action, and to a detail of the uses to which it may be applied.

* This hose may be made very perfect by tarring, and covering it with leather a second time; the seams of the first and second coverings, being placed on opposite sides. Flexible pipes thus prepared, will be found useful for many other purposes, besides that here mentioned.

Suppose that as much water were poured into the cask A, Fig. 1, as would fill the lower apartment, and rise above the partition B, one or two inches. Let fig. 4, be a representation of the cask, when supplied with this necessary quantity of water. When the machine is at rest, the top of the bellows being loaded with lead, is depressed as low as the folding of the leather will permit, and the small space which remains in consequence of this folding, between the top of the bellows and the bottom of the cask, becomes filled with water, which leaks through the upper valve. Let the bellows be extended by depressing the handle at *a*. The upper valve will shut tight; and a quantity of water equal to the bulk, which the bellows will gain by extension, will rise through the pipe D, to the external apartment; and the weight of the atmosphere being removed from the top of the valve, in the bottom of the cask, the air will press through the suction pipe I H, lift this valve, and occupy the vacant space within the bellows. If the hand be then removed from the handle, the lead in the top of the bellows will again depress it, and the air drawn into them, being thereby compressed, will force open the upper valve, and ascend. During its ascent, it will receive a strong lateral tendency from the hood, which will make it pass out at the open side of the hood, into that compartment which is immediately over this opening; and as by turning the rod, this part of the hood may be brought under either compartment, so the air may be thrown into either of them; and one of them being filled with one species of gas, the other may be filled with another species; nor can there be any danger of mixture; because as the pipe D, is shorter than the sheet E E, any superabundant quantity of air, which may be thrown into either compartment, will pass up the pipe and escape.

In Fig. 4, the bellows are represented as nearly depressed; and the air issuing from the open side of the hood into the compartment immediately over it, which is about half filled with air. The other compartment, is represented as being completely full of that fluid. The water is represented in commotion, that the action of the machine may be strongly marked; but the motion of this fluid is in reality so gentle, that the regularity of a blast is not thereby perceptibly affected.

If it be desired to fill both compartments with one kind of air, without the trouble of turning the hood; by opening the cock of communication in the pipe Y, any air which may be thrown into either compartment, will divide itself equally between both of them.

It must be obvious, that the air in the compartments on each side of the sheet and pipe of copper E E, D, Fig. 4, is subject to hydrostatic pressure; and that of course, it will pass out at the pipes of delivery unless stopt by the cocks. These pipes are omitted in Fig. 4, but have been already described, together with their cocks, at M N O, m n o, Fig. 1.

The leather and joints of the bellows, are evidently subjected to the weight of a considerable column of water; but this pressure being external, tends to tighten them, and renders this part of the machine so perfect, that if the orifice of the suction pipe be closed, it will be found impossible to raise the top of the bellows, without the immense force which would be necessary to produce a vacuum within them. This would not be the case if the smallest leakage took place.

CHAPTER III.

APPLICATION OF THE HYDROSTATIC BLOW-PIPE, TO THE USES OF THE MOUTH BLOW-PIPE, AND TO THE PURPOSES OF THE ENAMELLERS' LAMP.—MANNER OF SUPPLYING IT WITH THE GASES—AND OF APPLYING IT TO THE SUPPLY OF COMBUSTION WITH OXYGEN GAS.

IT is now time to give an account of the purposes to which the Hydrostatic Blow-Pipe may be applied, and the manner of applying it to them.

This instrument may be employed to supply with atmospheric air, a small flame for the various purposes of the mouth Blow-Pipe. To effect this, it is only necessary to place a lamp, or candle, on the stand T V which is upheld by the screw S, Fig. 1. By raising or lowering this screw, or by sliding backward or forward, the block through which it passes, the stand may be so adjusted, as that the strait mouth piece X will just enter the flame. The handle must then be worked, until the blast obtains the proper strength. This generally happens when the water has risen above the partition B, three or four inches. If it should be raised higher, the blast may be regulated by turning the cock more or less at N.

When an operation is to be performed on a subject which cannot be held over the table: by fixing the small hose and Blow-Pipe a b, Fig. 7, into one of the conical mouths O, o, of the pipes of delivery, and by placing a lamp or candle on the edge of the table, an operator may with the subject in his hand expose the proper spot to the flame. In this way glass matrasses filled with liquors, have been hermetrically sealed.

Nothing can be more steady, than the stream of air emitted by this instrument. The falling off in pressure, arising from the descent of the water, does not perceptibly affect the flame, in a blast of six minutes duration; and in the mean time, the handle may be depressed so gently, that the most strict observation will not discover the least unsteadiness to be produced by it. Or if the machine be filled with air; by opening the cock more or less, an equable blast may be supported for more than the space of an hour.

In order to supply the enamellers' lamp with air by means of the Hydrostatic Blow-Pipe, it is only necessary to substitute this instrument, for the bellows commonly used for this purpose. There will then be nothing novel in the manner of operating, excepting, 1st. That the relative situation of the flame and the pipe is to be regulated by turning the screw S, or by sliding backward or forward, the block through which it passes; and, 2dly. That in lieu of the frequent movement of the foot, necessary with the common bellows; in the space of one minute, and with fifteen strokes of the handle, as much air may be drawn into the Hydrostatic Blow-Pipe as will blow for one hour; and as the cask and pipes are completely air tight, the blast may be stopt, or its strength increased or diminished at pleasure, by turning, more or less the cock of the pipe delivering the air.

The flame of the enamellers' lamp is not used exclusively, for the purposes of the artist from whom it takes its name. It is this modification of the principle of the Blow-Pipe, which is applied to the moulding of glass instruments. But in heating glass with this flame, an inconvenience arises from the impossibility of exposing both sides of any subject to the same heat, unless it be constantly turned round; for if only one side of a large glass tube be applied to the flame, the part exposed to its action will be fused, before the other will be softened, and if it be turned round constantly, a much longer time will be required to melt it. Indeed some large tubes of refractory glass, which are not to be melted while undergoing this rotatory motion, may be readily fused in any spot constantly exposed to the action of the flame.

In order to produce a flame which should be free from the inconveniences just described, I procured the oblong lamp with two wicks W, X, Fig. 1. It may be observed, that these wicks are fixed on two plates, which slide in a groove, in the direction of the length of the lamp. They may therefore be made to approach to, or recede from each other. This lamp being as represented in the engraving placed on the little stand T V, so as that one of the wicks was before the orifice of the straight mouth-piece, above X; the bent Blow-Pipe at W was so adjusted to the other wick, that when they were both lighted, and a blast passed over them, their flames met each other as represented in the plate. The result of this was, that a much larger tube could be fused by the united action of two flames, than could be melted with one of them; and the parts being more equally heated, a bend could be made more regularly, and with less danger of collapsing.

It may be proper to observe, that the machine represented in the plate is much more complex and expensive, than is requisite for the purposes of the mouth Blow-Pipe, or enamellers' lamp, simply. But it is expected that artists availing themselves of the principle of the machine, will reject those appurtenances, which are unnecessary to their peculiar purposes.*

THE Hydrostatic Blow-Pipe may be filled with any of the gases, by exhausting them from the inverted jars, of the pneumato-chemical apparatus: and if it be desired to confine different species of gas, by closing the cock of communication between the compartments; one of them may be filled with one kind of gas, and afterwards by turning the hood, the other compartment may be filled with another kind.

* The cost of the machine represented in the plate, was about twenty dollars, but a machine fully equal to the purposes of the mouth Blow-Pipe, or enamellers' lamp, may be made for one fifth of that sum.

To make this understood; let *a*, Fig. 5, be a pneumato-chemical tub, with a shelf *c*, and an inverted glass jar *b*. Suppose that the tub were filled with water, and the jar with gas. Lute the pipe J, Fig. 1, to the mouth of the suction pipe at I; pass the syphon L under the jar as may be observed in Fig. 5, and then extend the bellows. The bellows will become filled with the air of the jar, and this being discharged into that compartment of the cask, which is over the open side of the hood, the bellows will be ready for another extension; the repetition of which would soon exhaust the jar of its air, although it should be of the largest size.

This method of filling the machine, is very convenient in a laboratory well supplied with pneumato-chemical apparatus. But it is a principal convenience of the Hydrostatic Blow-Pipe, that it may be filled with any gas, immediately from the retort, bottle, or matrass, made use of in obtaining it. Let D, Fig. 6. be a separate representation of the pipe D, Fig. 1. Let B be a matrass containing the substance from which the air is to be obtained, and let C be a syphon luted to the neck of the matrass. The air issuing from the matrass, must be emitted from the mouth of the syphon at the lower end of the pipe D. Suppose that this pipe were in its proper situation at D, Fig. 1. The air issuing from the matrass, would be discharged into that compartment of the cask, under which the mouth of the syphon should be placed, and if the cock at Y should be closed, this compartment alone would become filled; but if this cock should be open, the air would divide itself equally between both compartments. It must be obvious, that while one matrass and syphon, are employed in filling one compartment, with one species of air, the bellows, or another matrass and syphon filled with different substances, may be employed in filling the other compartment with another species of air; and thus the oxygen, and hydrogen gases or oxygen gas, and atmospheric air, may at the same time be confined in the same vessel, without their mixing with each other.

Those who desire to experiment largely with oxygen gas, will find it advantageous, to make use of a cast iron matrass, with a short and large neck narrowing inwards, and about fifteen inches of a gun barrel. The neck of the matrass being made large and short, it will not only be easily filled, but will be readily freed from any caput mortuum which may be left in it. The gun barrel, must be ground to fit the neck of the matrass.

The syphon for conveying the gas into the cask, may be fitted to the gun barrel with a cork.

THE philosophical world has been for some time acquainted with the intense heat produced by combustion supported with oxygen gas. By means of the Hydrostatic Blow-Pipe, every artist may, with little trouble and expense, avail himself of the intense heat produced by this combustion.*

Probably there are not at present many operations in the arts, which require greater heat than may be produced by the ordinary means; but it is certain, that the knowledge of a process cannot precede an acquaintance with the heat necessary to effect it; and this most intense fire, being placed within the reach of the artist, it is highly probable, that cases may be discovered, in which it may be applied with convenience and utility.

The most convenient way of making use of oxygen gas for small operations, is to supply one of the compartments of the Hydrostatic Blow-Pipe with that gas; to retain the gas thus confined for those moments when the greatest heat is required; and by means of the other compartment, to make use of atmospheric air when the heat produced by it is sufficiently intense. It must be obvious, that if the conical mouths, O, o, of the pipes M, N, O, m, n, o, Fig. 1, be furnished with straight mouth pieces, that any lamp or candle placed on the stand T V, may be readily shifted from one mouth piece to the other, when it shall be desired to expose any subject successively, to the heat produced by atmospheric air, and oxygen gas.

* In a former page I mentioned the Gazometer of Lavoisier as being too complicated for ordinary application to the supply of oxygen gas— I should also have noticed the Apparatus of Sadler, and the Gazometer of Seguin, but if I am not mistaken, these, although very ingenious inventions, are liable to the same objection.

If it be wished to make use of the heat produced in the combustion of charcoal with oxygen gas. After having confined a sufficient quantity of this gas; it will be necessary to fix in the conical mouth of the pipe, communicating with the compartment containing the gas, the larger end of a common brass Blow-Pipe, the orifice being directed downwards. Under this orifice, the body to be acted on must be placed, supported by a piece of charcoal, in the form of a parallelopiped, the charcoal being ignited in the part contiguous to the body. Things being thus arranged, by turning more or less, the cock of the pipe in which the Blow-Pipe shall be fixed; a stream of oxygen may be precipitated on the burning spot, with the proper degree of rapidity*.

This method of supporting the combustion of carbon with oxygen gas, is nearly the same as that by which the celebrated Lavoisier performed his experiments; excepting that in the place of the Hydrostatic Blow-Pipe, he made use of his Gazometer.

* In detailing the uses of the Hydrostatic Blow-Pipe, it may be proper to mention the facility which it gives to the employment of the gases, for medical purposes. When this machine is filled with any gas, the bag to be made use of in respiring it, may be inflated by fixing it to the mouth of the pipe of delivery, communicating with the gas.

CHAPTER IV.

EVILS EXPERIENCED IN OPERATING WITH THE COMBUSTION OF CARBON AND OXYGEN GAS.—SUPERIOR HEAT OF COMBUSTION SUPPORTED BY THE HYDROGEN AND OXYGEN GASES.—ITS EFFECTS ON THE MOST REFRACTORY SUBSTANCES.

IN the introduction to this paper it was mentioned, that some experiments had been performed, which seemed to invalidate the opinion that the employment of larger quantities of oxygen gas, would be the only means of increasing the power of caloric. I shall proceed to give an account of these experiments; but will first retrace the ideas which led to them.

In operating with the combustion of carbon and oxygen gas, great evils were observed to result, from the difficulty of placing the subject of the operation in the focus of the heat, without interrupting the stream of air by which this heat was supported. Not only was the focus widened by this interruption, and the intenseness of the heat thereby lessened; but the stream of air oxydated those substances which were combustible, and cooled those which were otherwise, in the places where it impinged previously to its union with the charcoal. Added to this, the charcoal was so rapidly consumed, that the substance acted on became so much buried, that it was difficult to follow it with the eye, or the orifice of the pipe: and some substances were observed to run into the pores of the coal, and elude examination.

To avoid these evils it was thought desirable, that means might be discovered, of clothing the upper surface of any body which might be subjected to this species of operation, with some burning matter, of which the heat might be equal to that of the incandescent carbon, with which the lower surface might be in contact: or by which bodies might be exposed on solid supports to a temperature, equal or superior to that of the porous charcoal uniting with oxygen.

It soon occurred, that these desiderata might be attained by means of flame supported by the hydrogen and oxygen gases; for it was conceived, that according to the admirable theory of the French chemists, more caloric ought to be extricated by this, than by any other combustion.

By the union of the bases of the hydrogen and oxygen gases, not only is all the caloric of the oxygen gas evolved; but also a much larger quantity which must be necessary to give the particles of the hydrogen their superior power of repulsion. The product of this combustion is water in the state of steam which retains heat so slightly, that it acts merely as a vehicle to deliver it to other bodies. What is necessary to preserve to water its form of fluidity, is the only portion of the caloric extricated in this combustion, which is permanently abstracted.

The combustion of carbon with oxygen gas, has been hitherto considered as the hottest of all fires. The caloric evolved in this case proceeds from the oxygen gas alone, while the product of this combustion is carbonic acid gas, which abstracts the large quantity of caloric, necessary to give it the form of permanent air, but which adds nothing to the heat of the combustion. Hence it is evident, that more caloric is evolved, and less abstracted, in combustion supported by the hydrogen and oxygen gases, than in that supported by oxygen gas and carbon.

However the intenseness of the heat of combustion, is not only dependant on the quantity of caloric extricated; but also on the comparative smallness of the time, and space, in which the extrication is accomplished. But in this respect the aeriform combustible, has obviously the advantage over those which are solid, as its fluid and elastic properties, render it susceptible of being rapidly precipitated into the focus of combustion, and of the most speedy mixture with the oxydating principle when arrived there.

The opinion of the intenseness of the heat produced by the hydrogen and oxygen gases, thus upheld by theory, derives additional support from the practical observation, of the great heat of a flame supported by hydrogen gas while issuing from a pipe; and also of the violent explosion which takes place, when it is mixed with oxygen gas and ignited, for it appears that this explosion can only be attributed to the combination of an immense quantity of caloric, with the water which is either held in solution by these gases, or formed by the union of their bases.

Such was the reasoning, which originated the desire of employing the flame of the hydrogen and oxygen gases. But before this could be accomplished, it was necessary to overcome the difficulty of igniting a mixture of these aeriform substances, without the danger of an explosion. It was for the purpose of surmounting this difficulty, that the Hydrostatic Blow-Pipe was furnished with two compartments; by means of which the machine might be at the same time charged with different species of air, without any possibility of mixture. One of these compartments being supplied with oxygen, and the other with hydrogen gas; two common brass Blow-Pipes a, b, Fig. 8, were joined at their orifices to two tubular holes in the conical frustum of pure silver c, of which the mean diameter is one-third, and the length is three-fourths of an inch. The diameter of one of these holes is large enough for the admission of a common brass pin. The other hole is a third less. They commence separately on the upper surface of the silver frustum near the circumference, and converge so as to meet in a point, at the distance of a line and an half from the lower surface. In the space between the lower surface, and the point of meeting, there is a perforation of the same diameter as the larger hole. The manner in which this perforation, and the tubular holes communicate one with the other, may be understood from the lines in the form of the letter Y, in the transparent representation of the silver conical frustum at d. The pipes a b were then fitted into the mouths O, o, of the pipes of delivery, Fig. 1: so that the Blow-Pipe inserted into the larger hole of the frustum, should communicate with the compartment containing the hydrogen gas; and that the other should communicate with that, which contained the oxygen gas. The cock of the pipe communicating with the hydrogen gas, was then turned until as much was emitted from the orifice of the cylinder, as when lighted formed a flame smaller in size than that of a candle. Under this flame was placed the body to be acted on, supported either by charcoal, or by some more solid, and incombustible substance. The cock retaining the oxygen gas, was then turned until the light and heat appeared to have attained the greatest intensity. When this took place, the eyes could scarcely sustain the one, nor could the most refractory substances resist the other.

However it is worthy of notice, that the light and heat of this combustion do not become evident until some body is exposed to it, from which the light may be reflected, or on which the effect of the heat may be visible. This is not the case with combustion supported by oxygen and carbon; for no sooner is a stream of oxygen gas directed on ignited carbon, than an effulgence is produced, which impresses the mind of the beholder with an idea of the greatest heat being produced by it.

It is in this different appearance, of these different species of combustion, that we may discover the reason why philosophers have neglected the one; while they have bestowed much attention on the other.*

* The inferiority of the light emitted by the flame of the hydrogen and oxygen gases, to that which irradiates from bodies exposed to its action, adds one to the many instances in combustion, in which the quantity and colour of the light extricated, do not seem to be so much dependant on the quantity of oxygen gas consumed, as on the nature of the substances heated or burned. In this, therefore, we may find support for

In lieu of the conical frustum represented at c d; that at d e may be used. The tubular holes of this last mentioned frustum, do not meet, but deliver their air at separate orifices into an excavation in the lower part of the frustum. The dotted lines represent the tubular holes; and the arched line the excavation. This is about three lines in diameter, and enters into the silver about the same distance.

At f, are represented pipes which are used for the fusion of platina, or subjects of the larger kind. They consist of a large, and a small pipe, the orifice of the one, being inserted into that of the other; as may be understood from the dotted lines near f.

The purity of gases contained in the Hydrostatic Blow-Pipe, may be at any time examined by charging eudiometers, from the syphon and leathern pipes hanging to the cocks Z Z Fig. 1. These cocks are soldered to curved pipes, one of which is represented in the figure. By turning the cocks round, the mouths of the curved pipes may be brought down to the surface of the water; this gives a facility to the discovery of any heavier gas, which may be mixed with one which is more light; as the fluid whose specific gravity is greater, will be found on the surface of the water.

I shall now describe the changes effected on the most fixed and refractory substances, by the flame of the hydrogen and oxygen gases.

the idea, that the light extricated by fire, or emitted by heated bodies, proceeds not only from the decomposition of pure air, but from that of the combustible, or the heated bodies themselves.

In order to avoid a tedious recurrence to an awkward phrase, I shall generally in the subsequent part of this paper distinguish the flame of the hydrogen and oxygen gases, by the appellation of gaseous flame.

By exposure to the gaseous flame, either on supports of silver, or of carbon; barytes, alumine, and silex, were completely fused.

The products of the fusion of alumine and silex, were substances very similar to each other, and much resembling white enamel.

The result of the fusion of barytes, was a substance of an ash coloured cast, which after long exposure sometimes exhibited brilliant yellow specks. If it be certain that barytes is an earth, these specks must have been discoloured particles of the silver support, or of the pipes from which the flame issued.

Lime and magnesia are extremely difficult to fuse, not only because they are the most refractory substances in nature, but from the difficulty of preventing them from being blown on one side by the flame; nevertheless, in some instances by exposure on carbon to the gaseous flame, small portions of these earths were converted into black vitreous masses. Possibly the black colour of these products of fusion, may have been caused by iron contained in the coal; for in the high temperature of the gaseous flame, a powerful attraction is reciprocally exerted by iron and the earths.

Platina was fused by exposure on carbon, to the combustion of hydrogen gas and atmospheric air. But the fusion of this metal was rapidly accomplished by the gaseous flame, either when exposed to it on carbon, or upon metallick supports.

A small quantity of this metal in its native granular form, being strewed in a silver spoon, and passed under the gaseous flame; the track of the flame became marked by the conglutination of the metal: and when the heat was for some time continued on a small space, a lump of fused platina became immediately formed.

About two penny-weights of the native grains of platina, when subjected to the gaseous flame on carbon, became quickly fused into an oblate spheroid as fluid as mercury. This spheroid after being cooled was exposed as before. It became fluid in less than the fourth of a minute.

Had I sufficient confidence in my own judgment, I should declare, that gold, silver, and platina, were thrown into a state of ebullition by exposure on carbon to the gaseous flame: for the pieces of charcoal on which they were exposed became washed or gilt with detached particles of metal, in the parts adjoining the spots, where the exposure took place. Some of the particles of the metal thus detached, exhibited symptoms of oxydation.

As the fusion of lime and magnesia by exposure on carbon, was accomplished with great difficulty and uncertainty: it became desirable, that means might be discovered of effecting this fusion with greater ease.

By the union of the base of oxygen with iron, the whole of the caloric of this elastic fluid is supposed to be extricated. This consideration, together with some practical remarks on the heat of burning iron, induced me to employ the combustion of this metal, in conjunction with that of the hydrogen and oxygen gases.

Some pieces of iron wire, each of about half an inch in length, were quickly thrown into fusion and rapid combustion, by exposure on carbon to the gaseous flame. When either lime, magnesia, barytes, alumine, or silex, were thrown on the iron in this state, they became instantly melted and incorporated with the metal. It remains a question whether in this case the earths were fused or disolved; and whether the substances which resulted from their union with the iron, were mixtures, or combinations. If they were combinations, according to the present nomenclature, they should be denominated *ferrurets*.

The difficulty of igniting some substances which are only susceptible of combustion at very high degrees of heat, has hitherto excluded them from the laboratory. By means of the gaseous flame, such substances may be employed with the greatest facility, in small analytical operations.

Of the nature of the substances above described, are the carburets of iron; and some peculiar species of native coal.

Among the carburets of iron, the English plumbago is esteemed the best. Some pieces of this substance obtained from the best English black-lead pencils, were readily thrown into combustion by exposure to the gaseous flame, either on carbon, or on some larger pieces of American plumbago. It was found that either lime or magnesia were fusible when exposed to the fire thus produced. This however, may have been caused by the iron contained in the carburet, for the fused earths, and plumbago, generally adhered to each other.

There is a peculiar species of native coal found on the banks of the Lehigh in this state, which it is extremely difficult to ignite: but when exposed to an high degree of heat and a copious blast of air, it burns yielding an intense heat without either smoke or flame, and leaving little residue. By exposure to the gaseous flame on this coal both magnesia and lime exhibited strong symptoms of fusion. The former assumed a glazed and somewhat globular appearance. The latter became converted into a brownish semivitreous mass.

The heat of the gaseous flame is very much dependent on the proportional quantities of the gases emitted. On this account the perforations in the keys of the cocks N, n, Fig. 1st, should be narrow and oblong to admit of a more gradual increase or diminution in the quantity of gas emitted.

I have now concluded my communications on the subject of this paper, and shall be happy if they have been found worthy of the time and attention bestowed on them by the society.